8.2 Automatic Watershed Delineation

Purpose

The BASINS *Automatic Watershed Delineation* tool carries out advanced GIS functions to aid the user in segmenting watersheds into several "hydrologically" connected sub-watersheds for use in watershed(s) characterization and modeling.

Application

The *Automatic Watershed Delineation* tool uses and expands ArcView and Spatial Analyst extension functions to operate watershed delineations in BASINS. The tool requires Spatial Analyst (ver. 1.1 or later) and Dialog Designer (ver. 3.1 or later) ArcView extensions installed on your PC. The delineation process requires a Digital Elevation Model (DEM) in ArcInfo grid format, and optionally a pre-digitized stream network (user provided blue lines, Reach File Version 1, Reach File Version 3 or NHD datasets) in ArcView shape (PolyLine) format. Once the delineation is finished a detailed report (*Topographic Report*) is added to the current project and the following resulting themes will be added to the *Basins View*: *Subbasins*, *Streams*, *Outlets* and (optional) *Reservoirs*. See *Watershed Delineation Output Data* for the content of the respective table of attributes. The report describes the elevation distribution within the watershed (or "hydrologically" not connected watersheds) and within each sub-watershed unit (subbasin). The themes carry the parameters of the watershed(s) characterization. As with the manual delineation tool, watershed analysis can be performed on delineated watersheds using the BASINS Watershed Characterization Report tools. Sample reports include landuse distribution, point sources (PCS), water quality data, toxic chemical releases (TRI), soil distribution (STATSGO), and elevation (DEM).

Key Procedures

- Load or select the Automatic Delineation extension (if not already done) by checking the relative box in the BASINS Extension Manager ("Watershed Delineators" category)

- Select the Automatic choice from the "Delineate" menu in *BASINS View*

- Load the DEM

- (Optional) Define the working area (Focused Area)

- (Optional) Load the stream network to be used for the delineation

- Run the preprocessing

- Specify the minimum sub-watershed area (critical source area)

- Review and edit the stream network points

- Run the calculation of the subbasin parameters

- (Optional) Locate the Reservoirs

Note: Only the DEM grid file is required for the delineation process.

Before you Get Started

First, verify that the Automatic Delineation extension is active in your BASINS project by typing Ctrl+B from the *BASINS View* (or selecting the BASINS Extension choice in the File Menu) and selecting the Watershed Delineators item from the Extension Categories dropdown list. The Automatic Delineation entry in the Basins Extensions list should be visible and selected (Screen 8.2.1).

Screen 8.2.1

If the Automatic Delineation entry is not selected (checked), click on it to select it.

Detailed Operations

Select the menu choice Automatic, from the *BASINS View* menu Delineate, to begin the automatic delineation process (Screen 8.2.2).

Screen 8.2.2

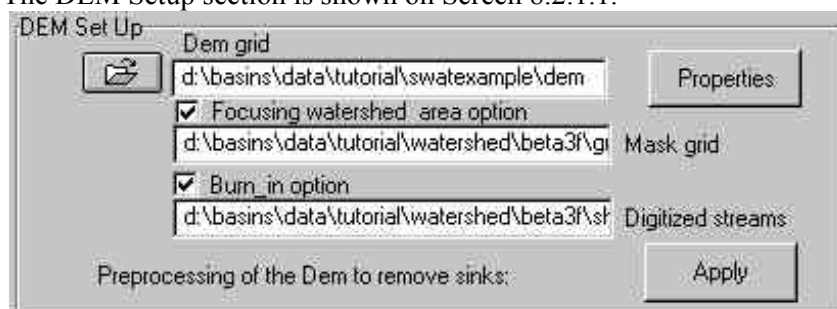The Watershed Delineation dialog will open (Screen 8.2.3).
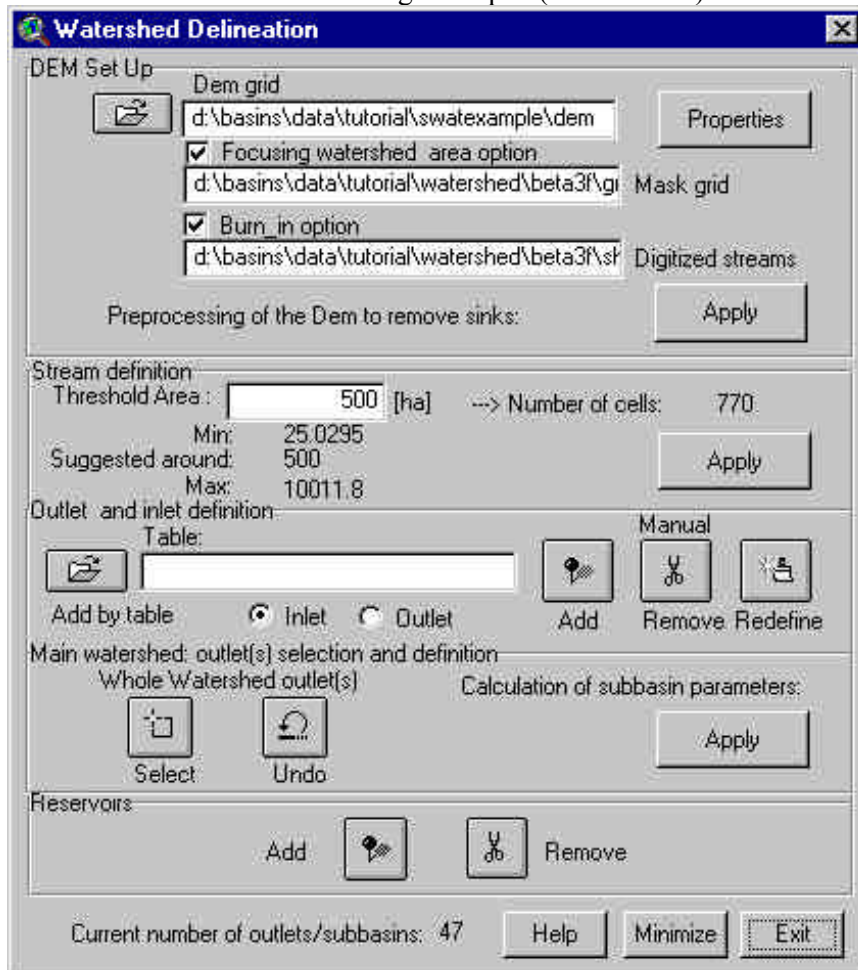
Screen 8.2.3

The dialog is divided into five sections: DEM Setup, Stream Definition, Outlet and Inlet Definition, Main Watershed Outlet(s) Selection and Definition, and Reservoirs.

8.2.1 DEM Setup

The DEM Setup section is shown on Screen 8.2.1.1.

Screen 8.2.1.1

One button loads the DEM grid map used to calculate all subbasin/reach topographic parameters. Two check boxes (options) load or create a mask grid and/or load a stream shape file.

To load or select the DEM grid, click the button beside the text box labeled "DEM grid" A dialog box is opened to specify which DEM map grid to use (Screen 8.2.1.2).
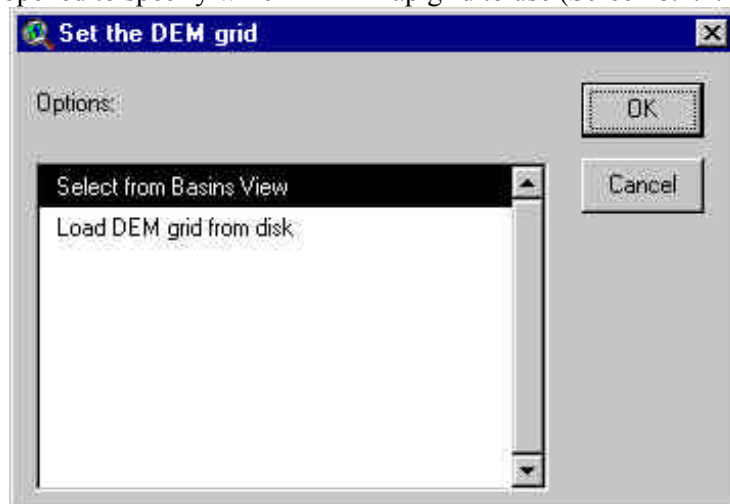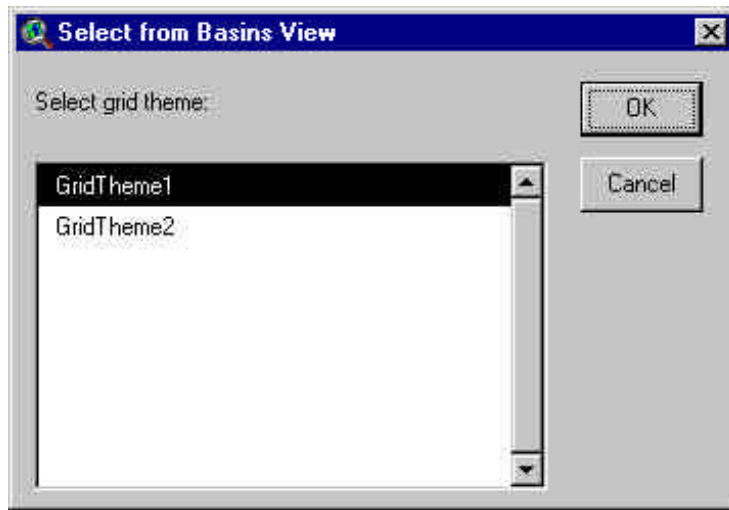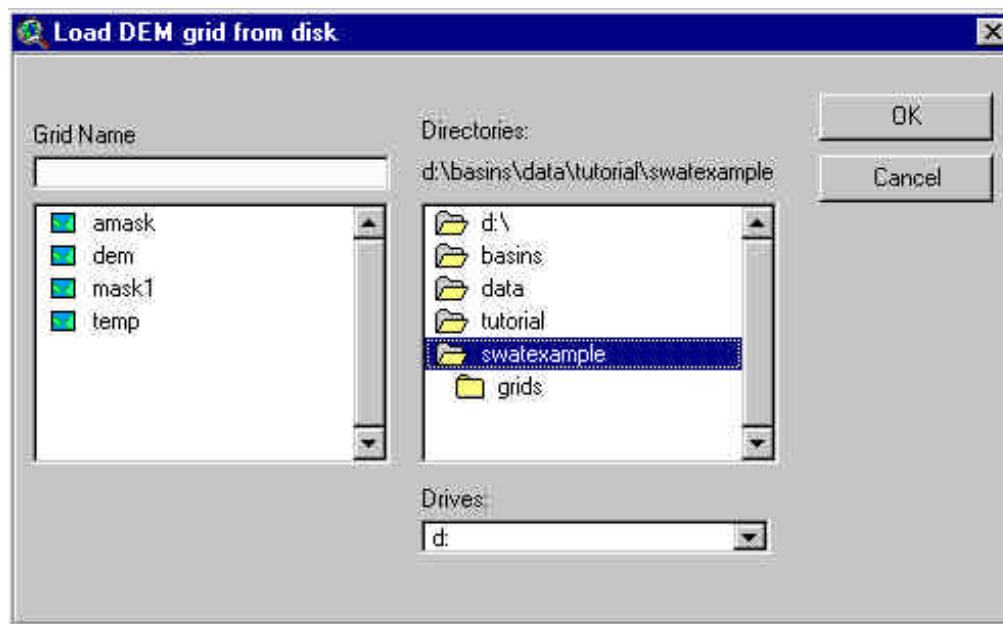

Screen 8.2.1.2

You may select a DEM grid that previously has been added to the *BASINS View* or load a DEM from a disk drive.

Tip: The DEM grid data provided with BASINS 3.0 has 3 arc second (around 90 x 90 meter) resolution. Alternative DEM data may be imported and used if you have access to higher-resolution-quality coverages. Higher-resolution DEM data will improve the delineations, particularly in areas with little topographical relief.

Click **OK** after the selection. If the first option was selected, the list of the grid themes in the *BASINS View* is shown (Screen 8.2.1.3) otherwise a grid dataset file browser (Screen 8.2.1.4) will appear to allow you to specify which DEM will be used.
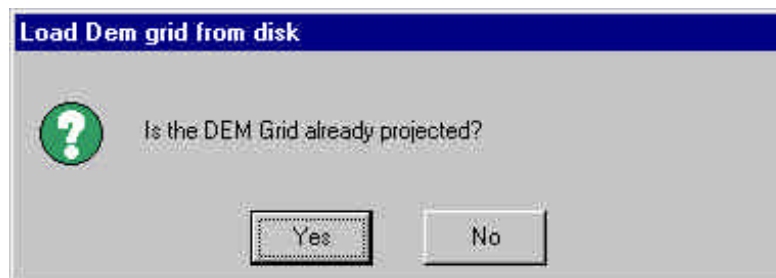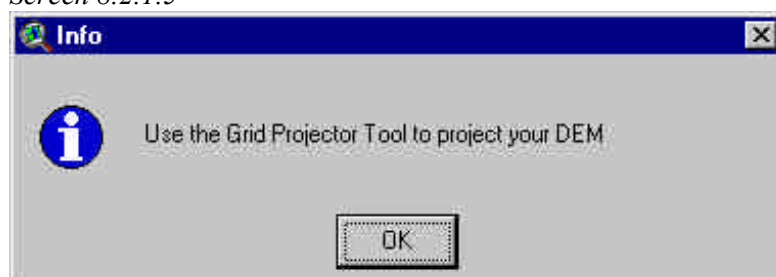
Screen 8.2.1.3

Screen 8.2.1.4

Select the name of the DEM map grid and Click **OK** (or double click the selection.) The loaded DEM grid should be already in the same projection as the rest of the data in the *BASINS View*. If the grid was selected from disk, a prompt box (Screen 8.2.1.5) will ask if the projections are the same and, if **No** is clicked, another dialog (Screen 8.2.1.6) will lead to the Grid Projector tool (See Grid Projector extension).
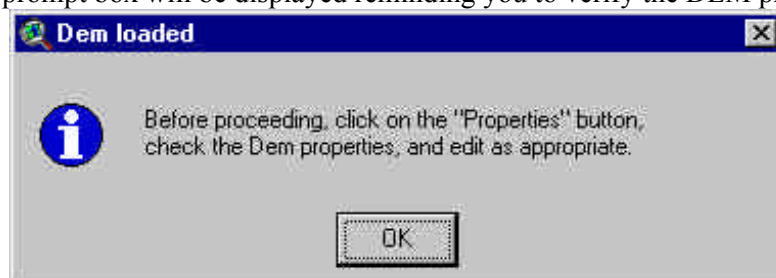
Load Dem grid from disk

Is the DEM Grid already projected?

Yes   No

Screen 8.2.1.5

Info   ×

Use the Grid Projector Tool to project your DEM

OK

Screen 8.2.1.6

Once the DEM is loaded, the grid data set path will be shown in the text box labeled "Dem Grid". A prompt box will be displayed reminding you to verify the DEM properties (Screen 8.2.1.7).
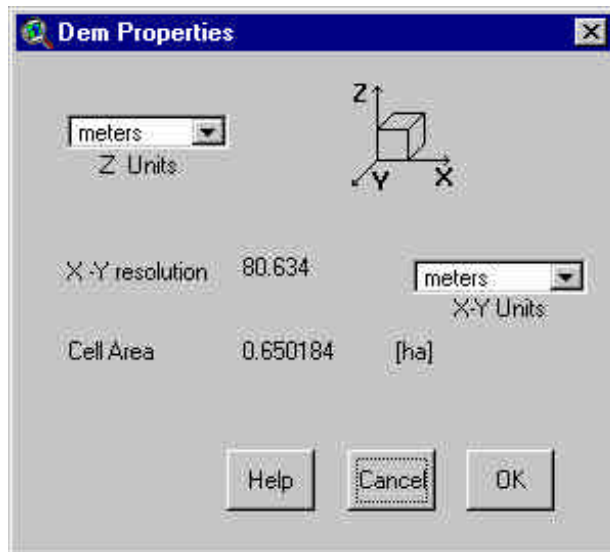
Dem loaded   ×

Before proceeding, click on the "Properties" button, check the Dem properties, and edit as appropriate.

OK

Screen 8.2.1.7

Properties Click the **Properties** button next to the DEM grid text box.

The *DEM properties* dialog allows you to verify and edit the DEM map properties (Screen 8.2.1.8) regarding the vertical and horizontal units of measure.

Screen 8.2.1.8

 Use the two drop down boxes to do this.

Note: Careful!! The DEM properties dialog should correctly report the horizontal and vertical units. Incorrect settings will affect the results of the watershed geomorphic parameterization. Obviously the numeric value of the DEM resolution is not editable.

Click **OK**

The *BASINS View* map units will be automatically set to the specified DEM horizontal units.

Once the DEM properties are set the **Apply** button (labeled "Preprocessing of the Dem to remove sinks:") will be enabled. The following two options need to be set before proceeding with the preprocessing of the DEM.

Focusing Watershed Area Option

The first option in the *Dem Setup* section allows you to import or create a grid map that masks out a part of the DEM grid. This map is not required but will reduce the processing time of the GIS functions.

Click the box beside the label "Focusing Watershed Area".

A check will appear in the box and a prompt dialog will open (Screen 8.2.1.9).
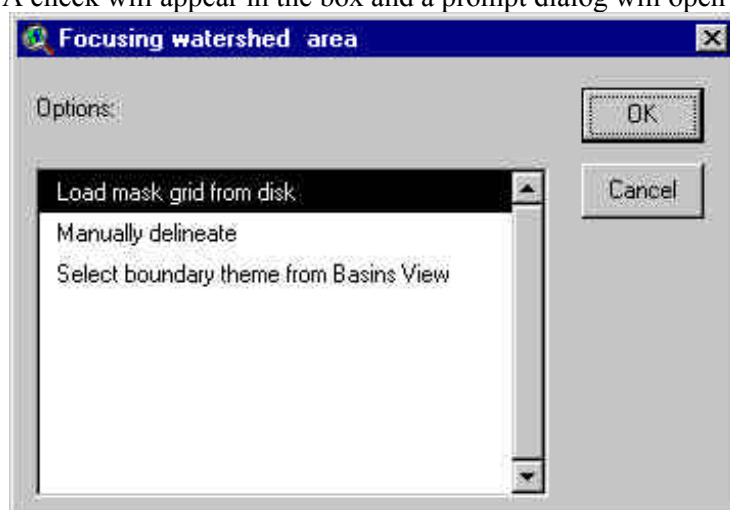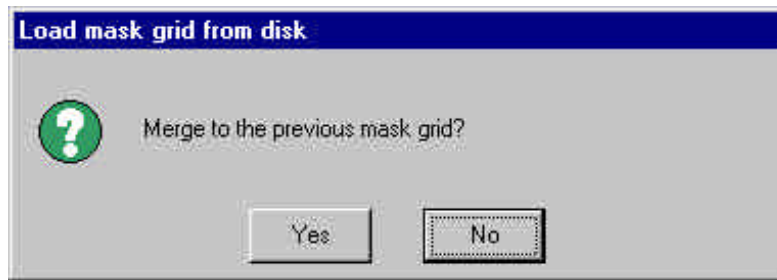

Screen 8.2.1.9

This dialog offers three options (to activate one option, select and click OK or double click the selection): The first option (*Load mask grid from disk*) allows you to add a grid map from a disk drive and select it for use in the delineation process. A grid data set browser is opened to load the mask grid (Screen 8.2.1.10).
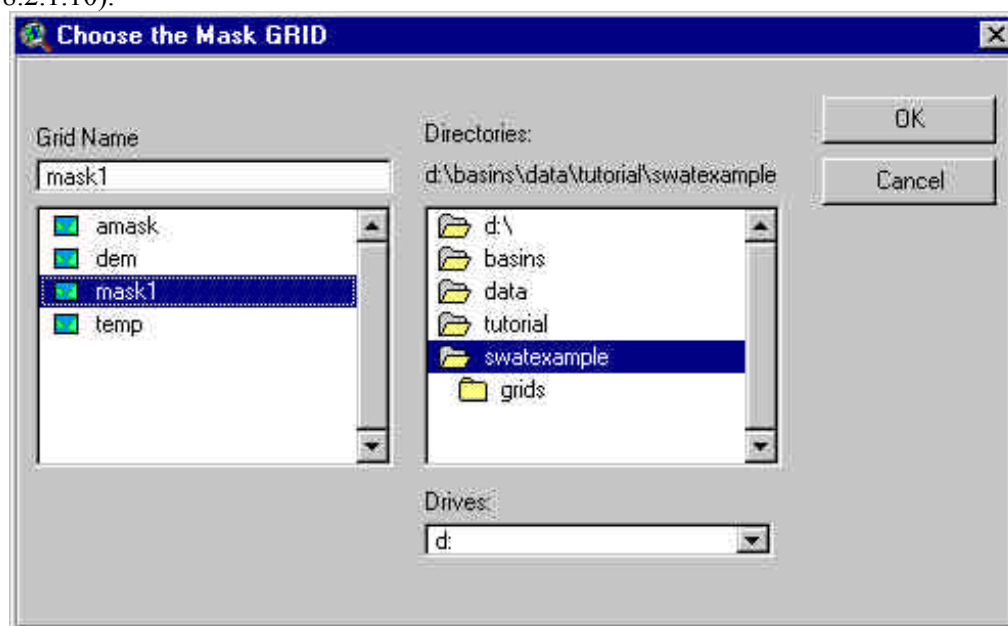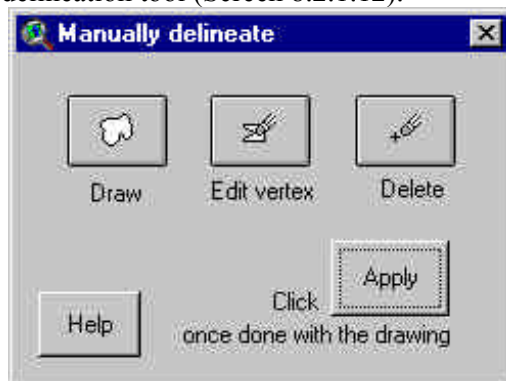

Screen 8.2.1.10

Select the name of the mask grid and click **OK** (or double click the selection). If a mask previously has been set, a prompt box will appear asking if you want to merge the new mask with the existing one (Screen 8.2.1.11).
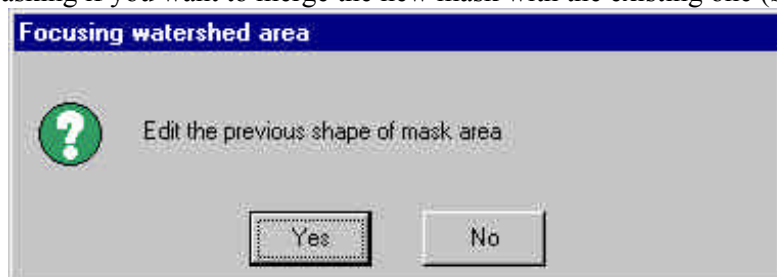
Screen 8.2.1.11

Click **Yes** to merge the new and the previous mask grid.
 Click **No** to skip merging.

The second option (*Manually delineate*) lets you draw and edit a polygon mask using the manual delineation tool (Screen 8.2.1.12).

Screen 8.2.1.12

If a mask polygon was previously used (using this option or the next one), a prompt box will appear asking if you want to merge the new mask with the existing one (Screen 8.2.1.13).
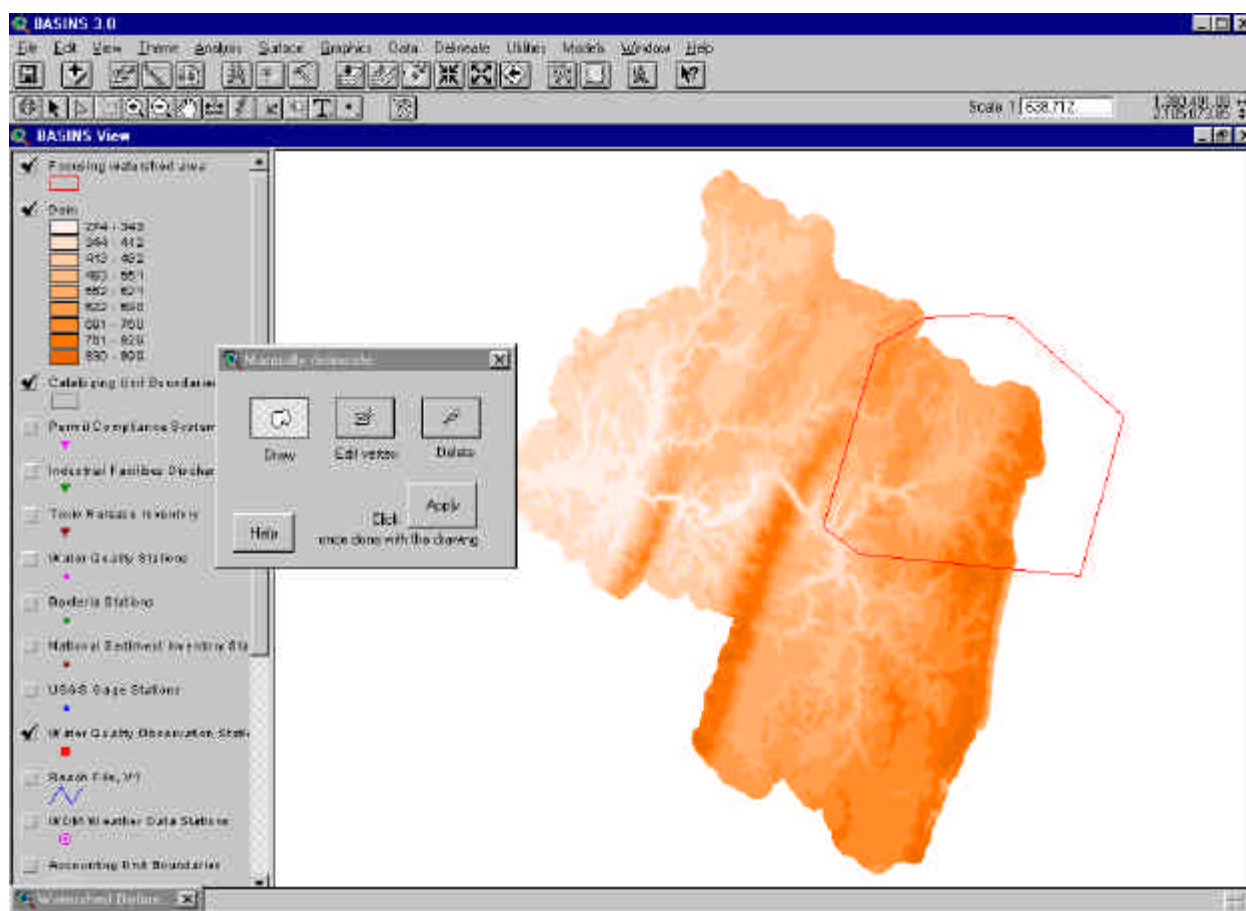

Screen 8.2.1.13

Click **Yes** if you want to include the previous polygon(s).

As you delineate the new mask, you can use the standard ArcView zoom-in and zoom-out tools if needed without closing the dialog.

Draw   Click the **Draw** button.

The cursor appears as a loop; click where you want the polygon to start; click each vertex around the polygon's boundary; then double-click the final vertex. Repeat the same procedure for as many polygons as are needed. The polygons are displayed as the Focusing watershed area theme (Screen 8.2.1.14).

Screen 8.2.1.14

Edit vertex To add a new vertex to a polygon, click the **Edit Vertex** button.

Move the cursor to the position on the line where you want the new vertex. When the cursor changes to a target, click. To move a vertex, place the cursor on the vertex you want to move and when the cursor changes to a crosshair, hold down the left mouse button and drag the vertex to the new position.

To delete a vertex, click the **Delete** button.

Place the cursor on the vertex you want to delete; when the cursor appears as a crosshair, press the **Delete** key. To delete multiple features at one time, use the mouse pointer to select the polygon(s) to be deleted. Press the **Delete** key to remove the selected polygons(s) from the *Focusing watershed area* theme.

When you are done drawing and editing your mask polygon, click the **Apply** button.

The *Focusing watershed area* polygon theme will be converted to a grid. If a mask has been previously set. a prompt box will appear asking if you want to merge the new mask with the existing one.

The third option (*Select boundary theme from BASINS View*) allows you to set the mask using a polygon theme that already appears in the BASINS View. A dialog box appears, allowing you to select a polygon theme from those in the *BASINS View* (Screen 8.2.1.15).
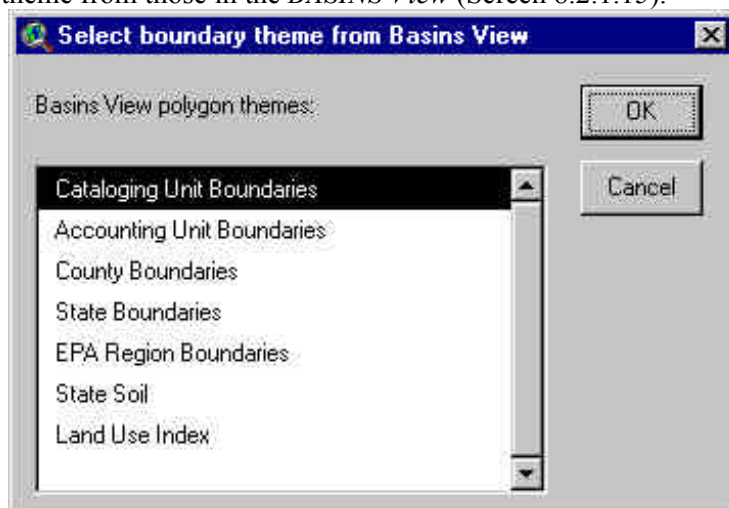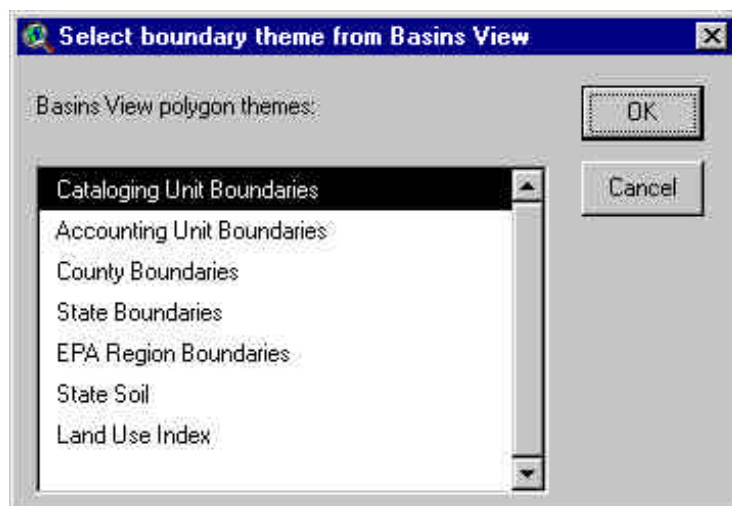

Screen 8.2.1.15

Select the name of the polygon theme and click **OK**.

Only the selected polygon(s) will be imported; a prompt dialog (Screen 8.2.1.16) will ask if you want to continue with the current selection. If none of the polygons are selected, all of the theme's polygons will be imported.
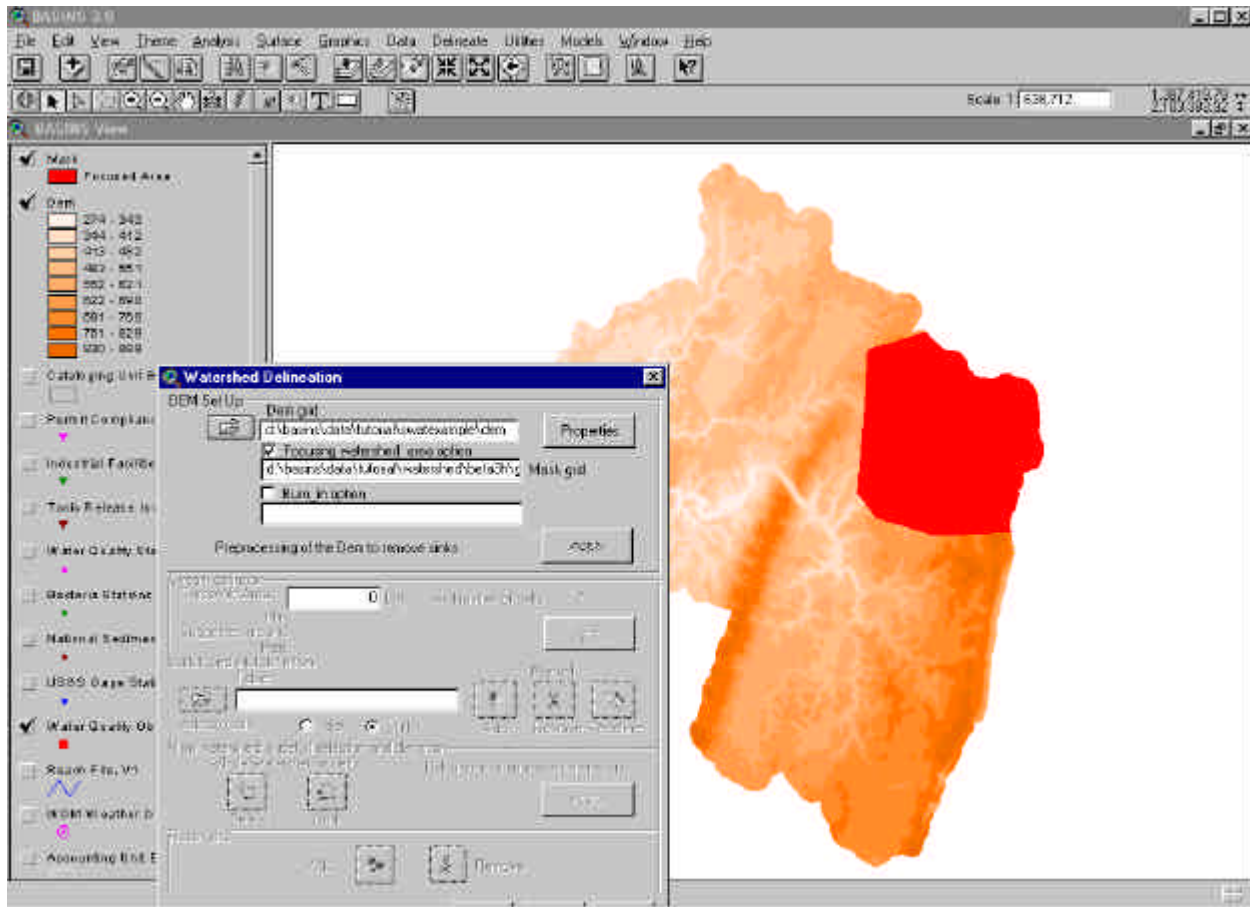
Screen 8.2.1.16

Tip: In order to use only selected features, you should set the selection before to activate this option.

If a mask has been previously set, a prompt box will appear asking if you want to merge the new mask with the existing one.

The mask map grid (named "Mask-Focused Area") will be added to the *BASINS View* (Screen 8.2.1.17) and the grid data path will be shown in the text box labeled "Mask Grid" in the *Watershed Delineation* dialog (Screen 8.2.1.17).
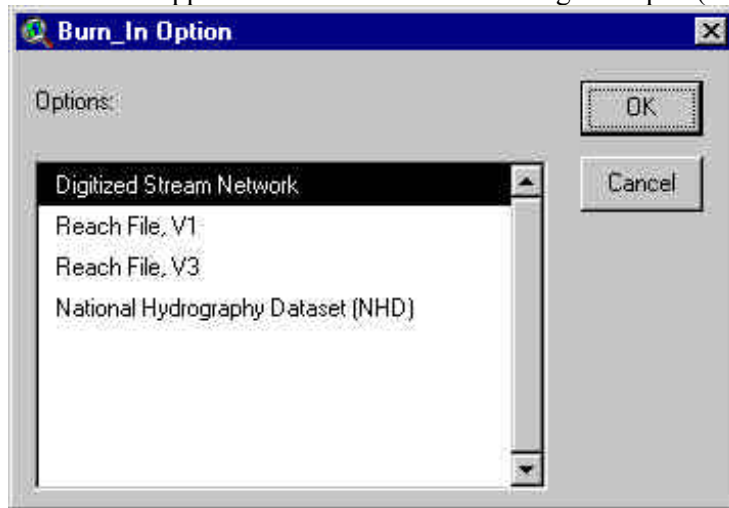
Screen 8.2.1.17

Note: The Analysis Mask of the Spatial Analyst Properties is now set. Eventual applications of Spatial
         Analyst commands will be now limited to the mask zone. In order to re-set the Analysis mask to
         the entire DEM, reload the DEM grid in the *Basins View* as described above (see 2).

Burning in a Stream Network

A stream network theme, such as user provided stream blue-lines, Reach File V1 or V3, or NHD datasets,
can be superimposed onto the DEM to define the location of the stream network. This network is then
used with the DEM grid to improve the process of hydrographic segmentation and determine the sub-
watershed boundaries. ☑ Burn_in option Check the box labeled "Burn_in option".

A check will appear in the box and a new dialog will open (Screen 8.2.1.18).

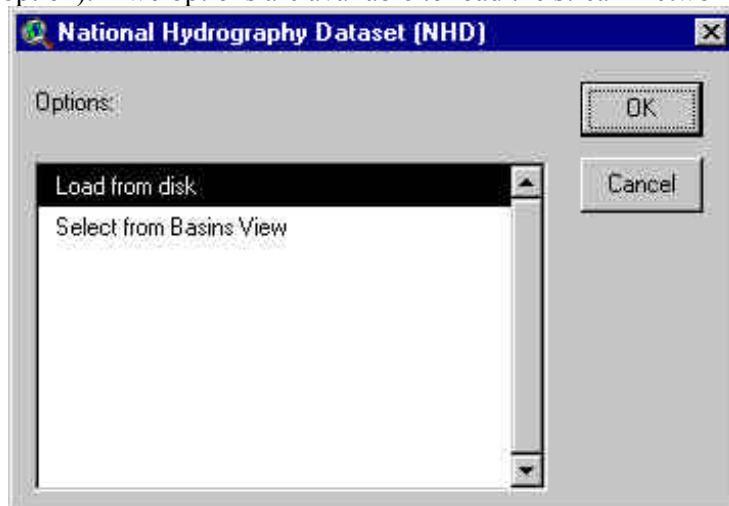*Screen 8.2.1.18*

Four options are available to specify the stream network*: Digitized Stream Network, Reach File V1, Reach File V3, and National Hydrography Dataset (NHD)*.
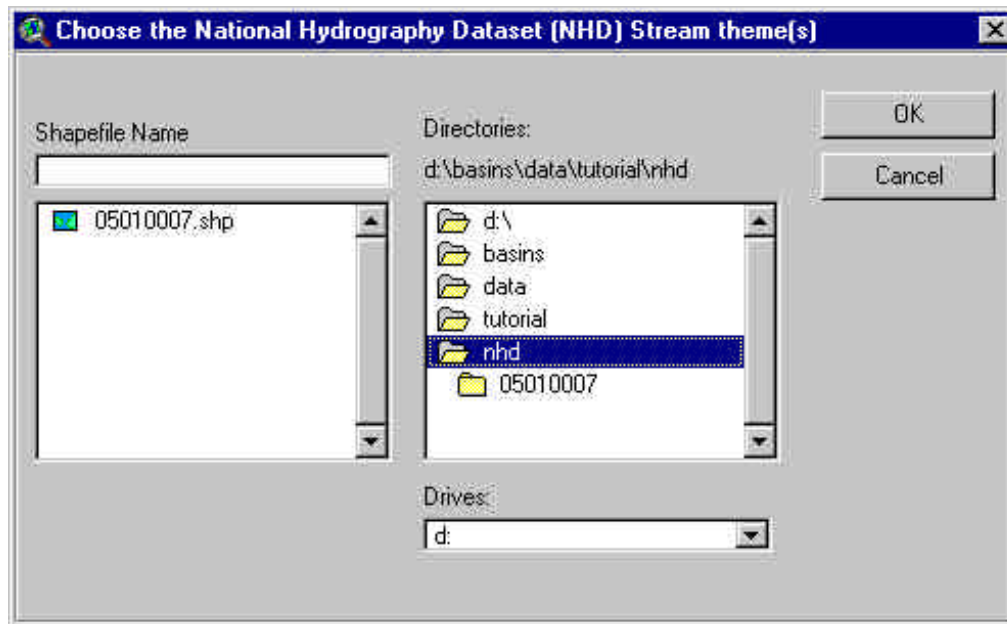
Click **OK** after the selection has been made (or double click the selection).

Another dialog box will open (the screen 8.2.1.19 shows the opened dialog when selecting the NHD option). Two options are available to load the stream network data set:
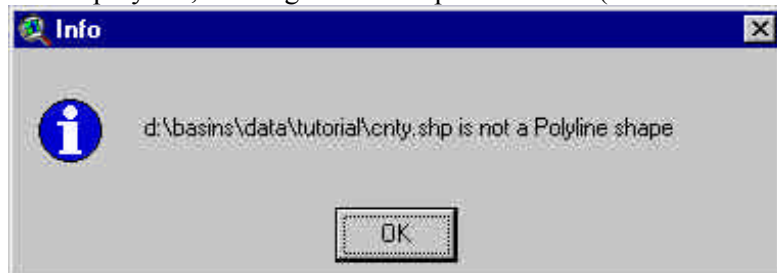

Screen 8.2.1.19

Load from disk. A file browser will appear (Screen 8.2.1.20) to allow you to select one or more shape files.
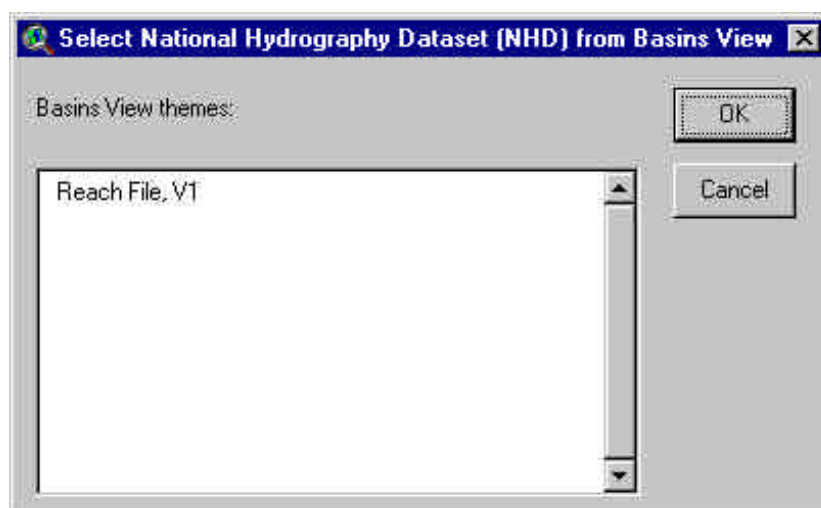
Screen 8.2.1.20

Select the file(s) (hold the Shift key for multiple selection) and click **OK**. If any of the selected shape files is not a polyline, a dialog box will report the error (Screen 8.2.1.21) and the process will be stopped

Screen 8.2.1.21

Tip: Use the *NHD import tool* to download Cataloging Unit based data sets from a USGS server and to write on disk the required shapes and tables.

Select from *BASINS View*. A dialog box is opened (Screen 8.2.1.22) which allows you to select a Polyline theme from those currently in the *BASINS View*. Select the name of the polyline theme(s) (hold the Shift key for multiple selection) and click **OK**.
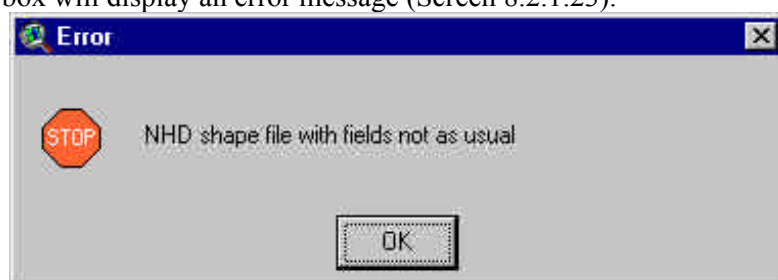
Screen 8.2.1.22

Tip: For *Digitized Stream Network* and *Reach File V1* options, only the selected features (or all of them if no selection was made) will be imported. If needed you should select the target features before checking the box for this option.


The selected theme(s) will be displayed in the *BASINS View* as a single theme named Digitized streams (multiple selected data sets will be merged).

If the *Reach File V3* or *NHD* option has been picked and the wrong data set has been selected a dialog box will display an error message (Screen 8.2.1.23).

Screen 8.2.1.23

The "NHD" option also requires the flow direction table (in dBase format) located in the same directory (The *NHD Import* tool makes it automatically).   The name of this table must be the same as the NHD shape postfixed by "rflow". A dialog error pops up if these conditions are not satisfied (Screen 8.2.1.24).
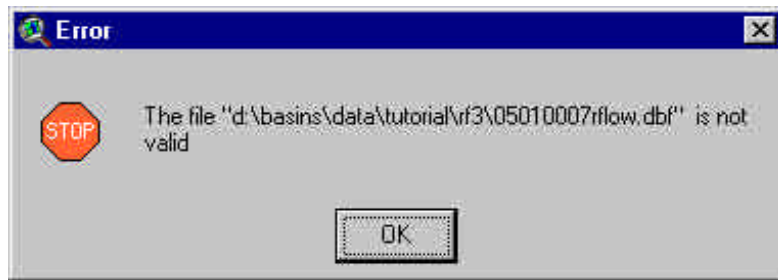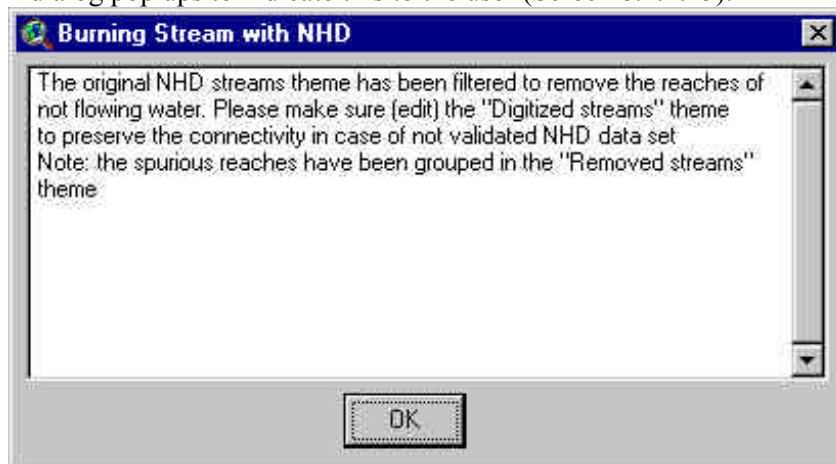
Screen 8.2.1.24

With the options *Reach File V3* and *NHD* the line sets are filtered to retain only the lines of flowing bodies of water. The filtering of the *Reach Files V3* and *NHD* themes is based on the data reported on the respective tables of attributes.
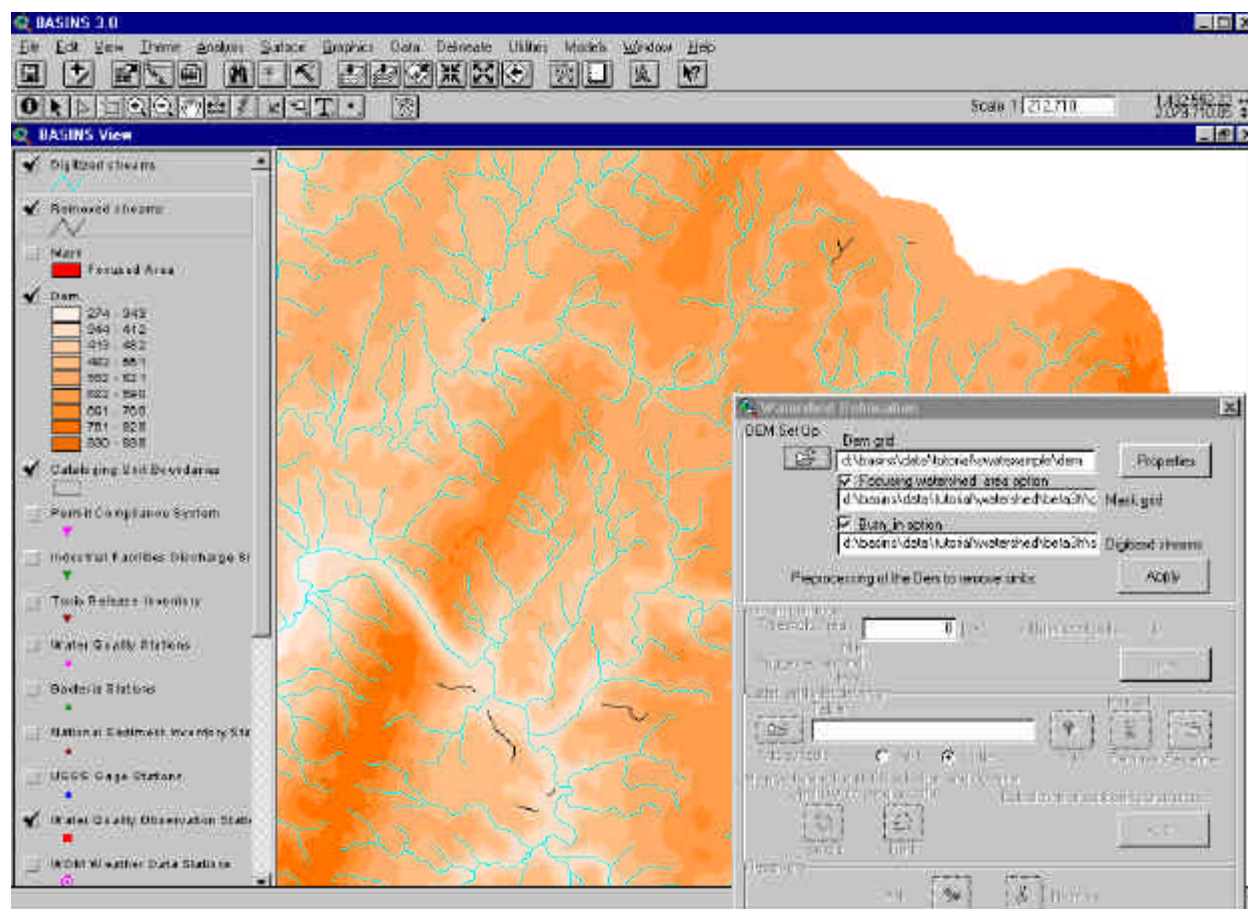
The filtered features (if any) from the selected themes are merged into a theme named Removed streams and added to the *BASINS View*.

A dialog pop ups to indicate this to the user (Screen 8.2.1.25).

Screen 8.2.1.25

The Digitized streams theme data path will be shown in the text box labeled "Digitized Streams" (Screen 8.2.1.26).

Screen 8.2.1.26

Tip: After filtering and before proceeding to the next preprocessing step, you should edit the *Digitized stream* theme to provide a continuous set of stream lines (e.g., draw lines through lakes and ponds, remove isolated reaches). For this task you can start an editing section of the *Digitized stream* theme and use the ArcView default tools in the *BASINS View*.

Note: The streams lines should not cross the edge of the DEM (or the Focused Area if a Mask was set) flowing away, barring the outlet line(s). Lines crossing the edge outwards could affect the resulting flow direction obtained burning the DEM.
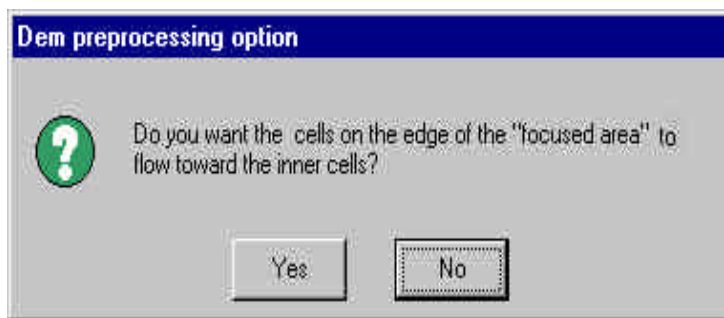

DEM Preprocessing
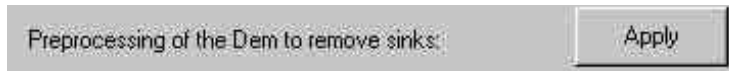
Once you have loaded the DEM grid, reviewed the DEM properties and set the optional themes, click the **Apply** button next to the label "Preprocessing of the DEM to remove sinks".

The interface will process the DEM map grid to remove all the non draining zones (sinks).

In the middle of the process a dialog pops up (Screen 8.2.1.27).

 Screen 8.2.1.27

Click **No** if all cells on the edge of the working zone need to flow away from the zone. Click **Yes** if the flow is calculated normally for edge cells with the edge being slightly lower than the cell.

A prompt box pops up when the map pre-processing is complete (Screen 8.2.1.28). Click **OK**.

Screen 8.2.1.28

TUTORIAL:

Load the DEM from disk   /basins/data/tutorial/swatexample/dem.

Review the DEM properties (leave the default DEM properties). Click **OK**.

(Optional) Load a Mask grid from disk   /basins/data/tutorial/swatexample/mask.

(Optional) Load NHD data from disk   /basins/data/tutorial/nhd/05010007.shp (Remove the streams crossing the edge of the Focused Area, barring the outlet reach).

Run the preprocessing of the DEM by clicking the **Apply** button.

8.2.2 Stream Definition

In this section the user will define the initial stream network and subbasin outlets. A minimum, maximum, and suggested sub-watershed area (in hectares) are shown in the stream definition section (Screen 8.2.2.1).
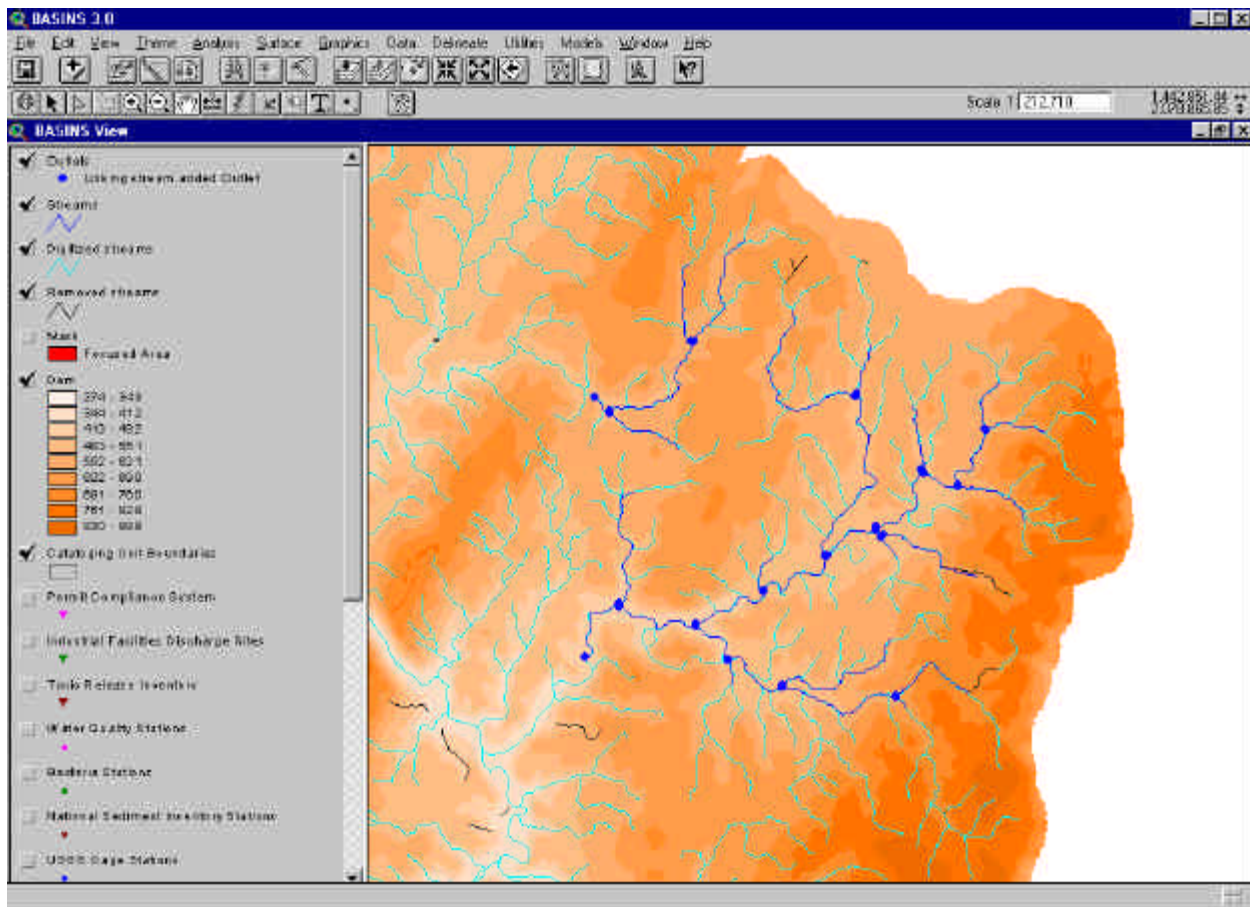

Screen 8.2.2.1

The user has the option of changing the minimum size of the subbasins. This function plays an important role in determining the detail of the stream network and the size and number of the created sub-watersheds. The threshold area, or critical source area, defines the minimum drainage area required to form the beginning of a stream. In the text box labeled "Threshold Area", type the upstream drainage area (in hectares) required to define the beginning of a stream. The smaller the specified number of hectares,

the more detailed the drainage network delineated by the interface. Click the **Apply** button.

Two themes are now added to the *BASINS View* and displayed over the DEM map grid (Screen 8.2.33): *Streams* (the current synthetic drainage network), and *Outlets* (the respective stream junction points).

Screen 8.2.2.2

The user can change the threshold value and re-run the stream and outlet definition routine or proceed with the next section to define outlet and/or inlet point sets.

8.2.3 Outlet and Inlet Definition

In this section the user has the option to refine the delineation by adding, deleting or redefining drainage inlets and watershed outlets (Screen 8.2.3.1).

Screen 8.2.3.1

The user can import a predefined table of inlets/outlets or manually (by clicking the mouse over the map on the screen) locate inlets/outlets on the map.

 Two radio buttons allow you to switch the current definition between inlets and outlets.

The table of attributes for the *Outlets* theme in the *BASINS View* (Table 8.2.3.1) contains the current locations of the following stream network points: outlets and inlets. Outlets are defined as the most downstream locations of the respective delineating subbasin. Inlets are defined as either the outlet of draining watersheds (part of the overall watershed that is not intended to be simulated) or point sources of discharge. In both inlet cases, the user needs to provide records of formatted discharge data. A particular kind of point source of discharge is the "Permit Compliance System" location: these points, as well as the input data records, will be defined using the respective BASINS database (see Chapter ??). The "Type"field of the table of attributes (see table 8.2.3.1 and 8.2.3.2)) and the associated legend (Screen 8.2.3.2) distinguish the kind of outlets/inlets.

Table 8.2.3.1. **"Outlets" Theme Table of Attribute Fields**

Field	Definition
Xpr	X coordinate in the data projection
Ypr	Y coordinate in the data projection
Lat	Latitude
Long	Longitude
Type	See Table 8.2.3.2
PCSId	Permit Compliance System Identification number(s) (if at least one of these location were imported)

Table 8.2.3.2. **Inlet/Outlet Types**

| Type	Meaning
L	Linking stream added subbasin Outlet
O	Table added subbasin Outlet
T	Manually added subbasin Outlet
P	Manually added Point Source
D	Table added Point Source
S	Permit Compliance System
I	Table added Draining Watershed Inlet
W	Manually added Draining Watershed Inlet
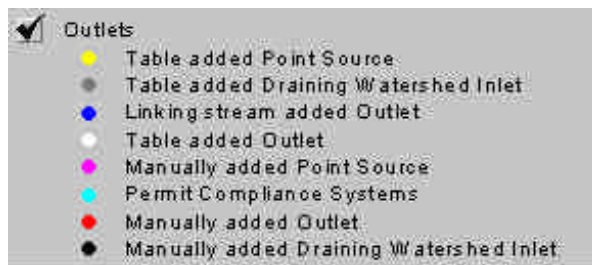
Screen 8.2.3.2

TUTORIAL:

Click the **Apply** button in the stream definition section.

Adding Outlets by table.

Outlet point locations (subbasin outlets) can be imported in the project using a dBASE table and the

following steps: Make sure the radio button labeled "Outlet" is

selected , click on the Add button next to the "Table" text box.

A file browser will appear (Screen 8.2.3.3) allowing you to select a dBASE table. Select the file name and click **OK** (or double click the selection).
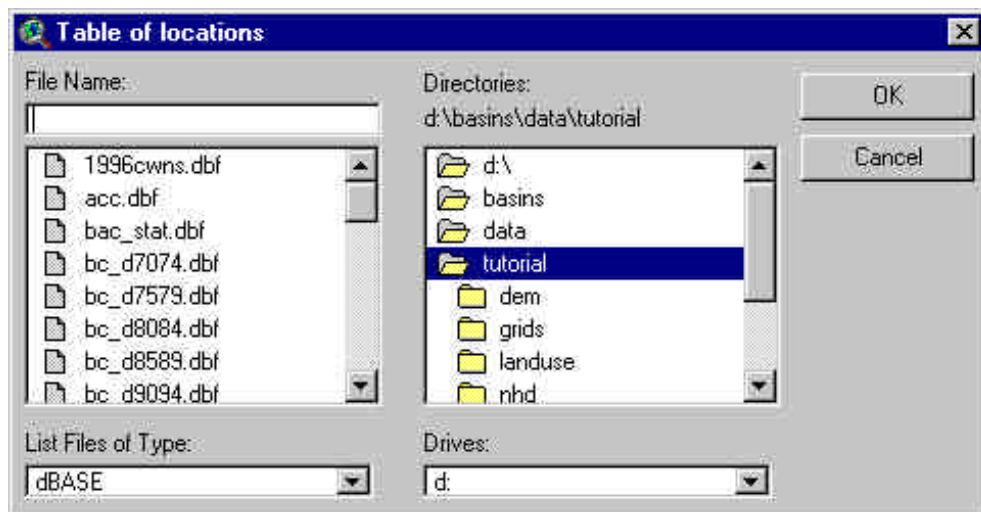
Screen 8.2.3.3

This table must have the same fields specified in Table 8.2.3.1. Only the subbasin outlets (use Type "O") are allowed. If a different "Type" value is specified, a dialog box will report an error like the one reported in Screen 8.2.3.4 and the loading process will stop.
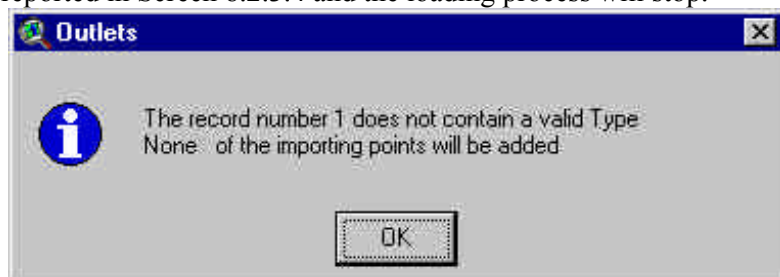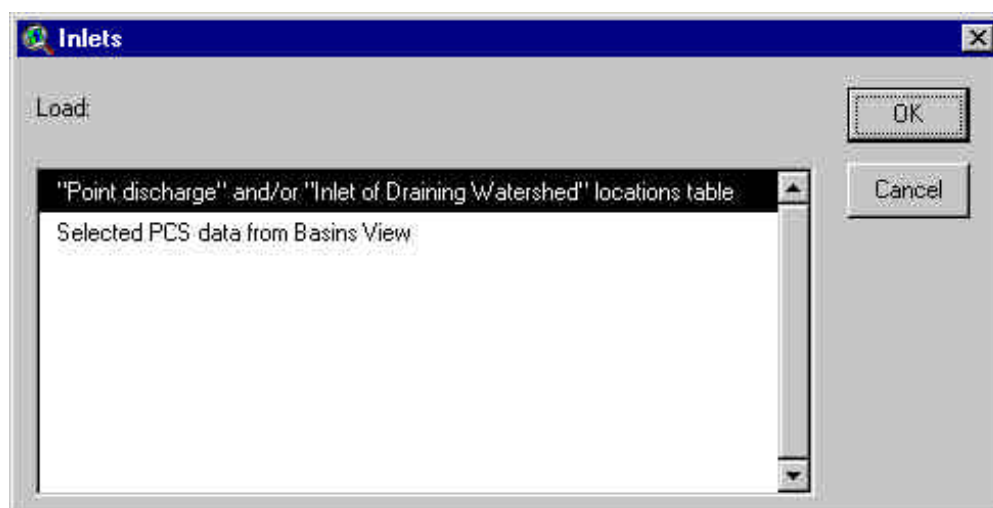

Screen 8.2.3.4

Once geocoded, the outlet locations will snap automatically to the closest reach of the Streams theme.

Note: Xpr and Ypr field data values have priority over the Lat and Long field data value for the definition of the point location on the map.

The DEM dialog box will automatically minimize, and the *BASINS View* will be redrawn on your map showing the added points.

Adding Point Sources or Inlets of Draining Watersheds from Tables, or Point Sources from the PCS data set Make sure the "Inlet" radio button is selected.

In the Outlet Definition section of the DEM dialog box, click on the Add button next to the "Table" text box. A dialog box will pop up (Screen 8.2.3.5).
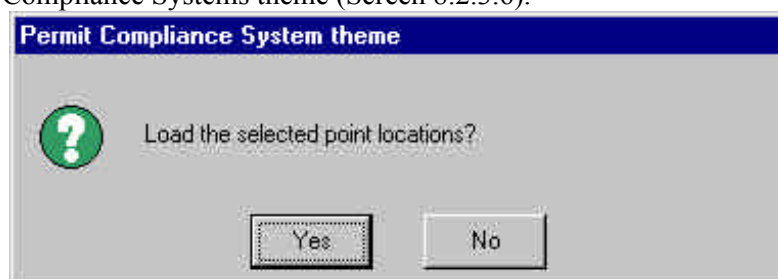
Screen 8.2.3.5

Two options are available: "Point discharge and/or Inlet of Draining Watershed locations table" and "Select PCS data from BASINS View".

The first option activates the same procedure described for Adding Outlets by Table. In this case, only Point Sources (Type "D") and Draining Watershed Inlets (Type "I") can be specified. If a Type other than these two is specified, a dialog box will report an error (as Screen 8.2.37) and the loading process will stop.

Tip: Select the target PCS locations in the *Permit Compliance Systems* theme before starting the add procedure.

The second option allows the import of Point Sources defined in the *Permit Compliance System* theme data set.

A prompt box will ask if you want to proceed with importing the selected points in the Permit Compliance Systems theme (Screen 8.2.3.6).

Screen 8.2.3.6

Click **No** to stop the loading process

Click **Yes**: only the selected PCS locations will be imported and snapped to the Streams theme and added to the Outlets theme (these locations will get a field Type value = "S"). The updated map will be redrawn with the new points displayed.

Manually Editing Outlets and Inlets

Outlets and inlets may be manually edited using the following steps.

Adding Outlets ⊙ Inlet ⊙ Outlet In the Outlet Definition section of the DEM dialog box, make sure the "Outlet" radio button is selected.

Add Click the Add button.

The "Watershed Delineation" dialog box will be minimized.

Move the cursor to the desired location(s) and click the left mouse button: the point will automatically snap to the closest stream line and the feature added to the "Outlets" theme and labeled with Type value "T."

When done adding outlets, maximize the dialog box. *Adding Inlets* In the Outlet Definition section of the DEM dialog box, make sure the Inlet radio button is selected. ⊙ Inlet ⊙ Outlet

Add Click the button labeled Add.

The *Watershed Delineation* dialog will be minimized. Move the cursor to the desired location(s) and click the left mouse button. A dialog box (Screen 8.2.3.7) provides two options: "Point discharge" and "Inlet of Draining Watershed."
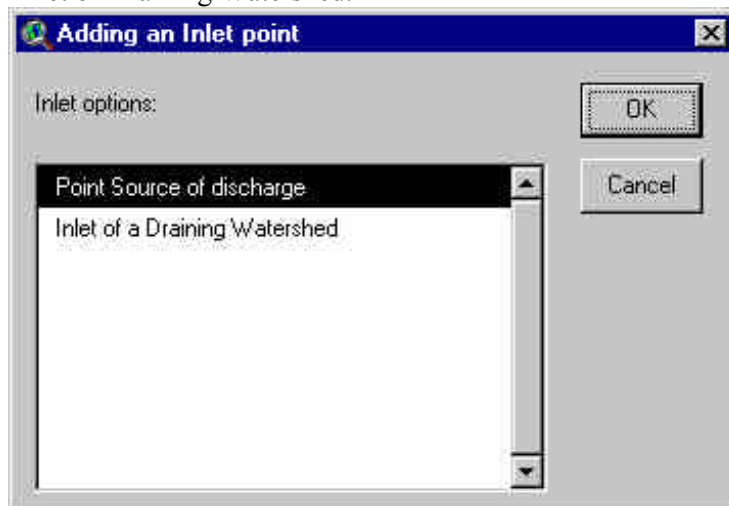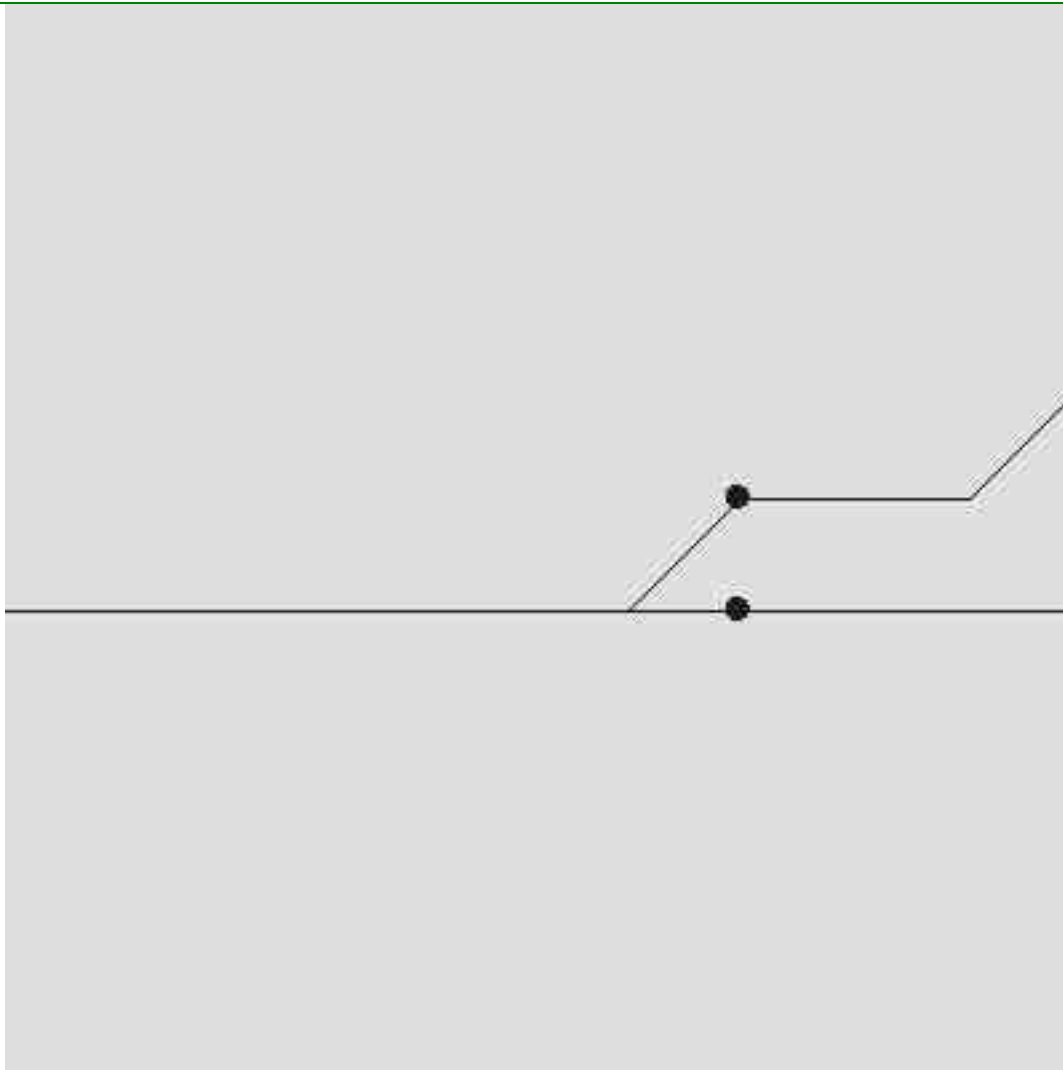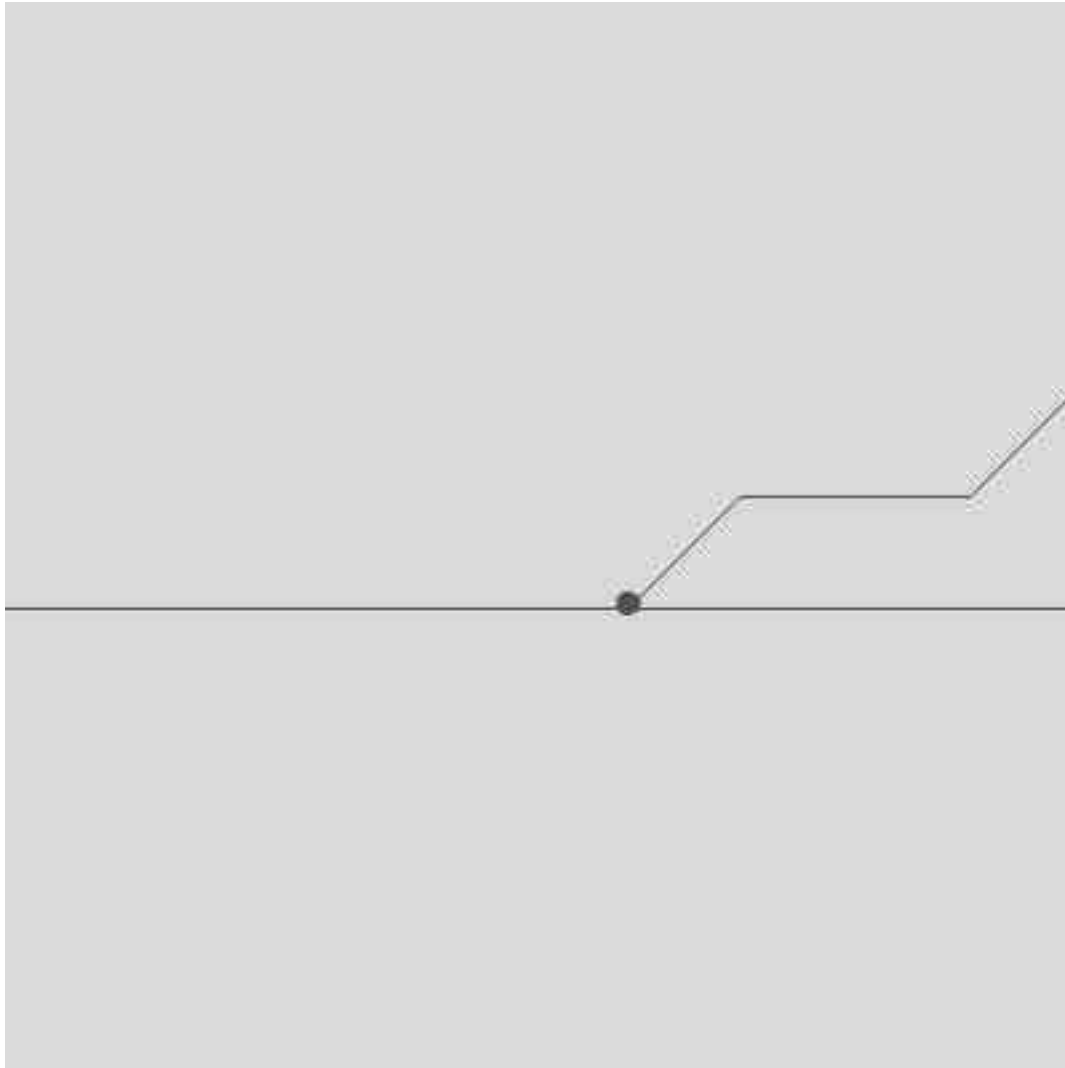

Screen 8.2.3.7

Once the option is selected, the inlet point will automatically snap to the closest stream line and the new feature added to the "Outlets" theme with a Type of "P" for Point Discharge or a Type of "W" for "Inlet of Draining Watershed."

When you are done adding inlets, maximize the dialog box.

Tip: Do not insert an outlet point in a junction cell. A detailed view of stream juncture points created by the interface is shown on the DEM map grid in Screen 8.2.3.8. The points are placed in the first cell of each branch of the stream. If these points are removed and replaced with one point in the junction cell (Screen 8.2.3.9), the interface will not be able to determine which branch of the stream is the correct stream line and will be unable to delineate the subbasins properly for the two stream branches.

Screen 8.2.3.8

Screen 8.2.3.9

Deleting Outlet and/or Inlet Points If necessary, zoom in on the inlet or outlet points to be deleted.
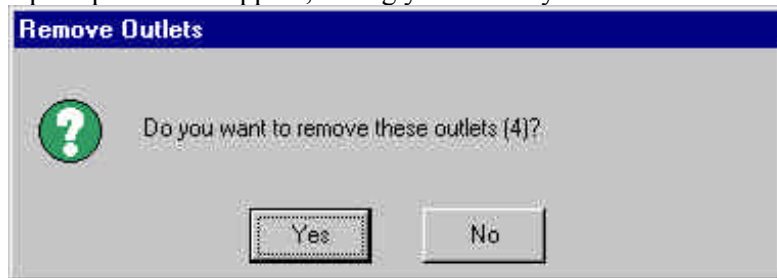

RemoveClick the button labeled "Remove".

The *Watershed Delineation* dialog will be minimized. Move the cursor to the location(s) you wish to remove.

Hold down the left mouse button and move the mouse to draw a box around the point(s) you wish to remove. Release the left mouse button.

A prompt box will appear, asking you to verify removal of the selected point(s).(Screen 8.2.3.10)

Screen 8.2.3.10

Redefining Outlets/Inlets Click the button labeled "Redefine".

The *Watershed Delineation* dialog will be minimized. Move the cursor to the desired location(s) and left click. Hold down the left mouse button and draw a box around the point(s) you wish to redefine. Release the left mouse button. A prompt box will open (Screen 8.2.3.11). Click the **Cancel** button to exit.
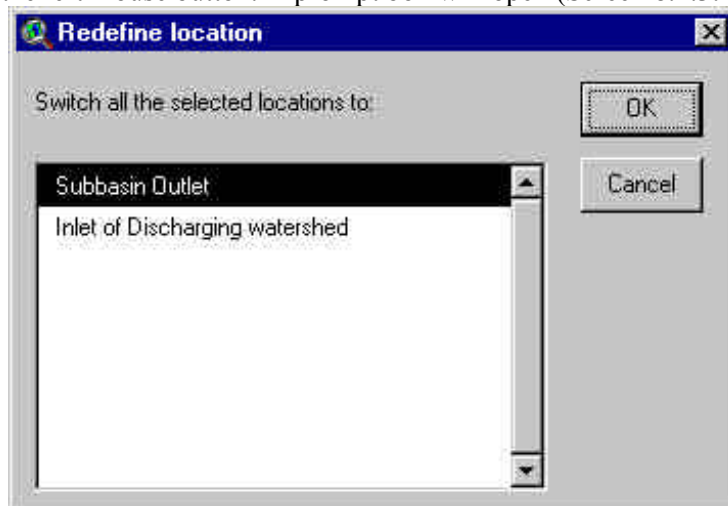
Screen 8.2.3.11

You may redefine one or more outlets to inlets and vice versa.

Point Source or PCS points can not be redefined. If one of these points is selected, a dialog box will report an error (Screen 8.2.3.12) and the process will stop.
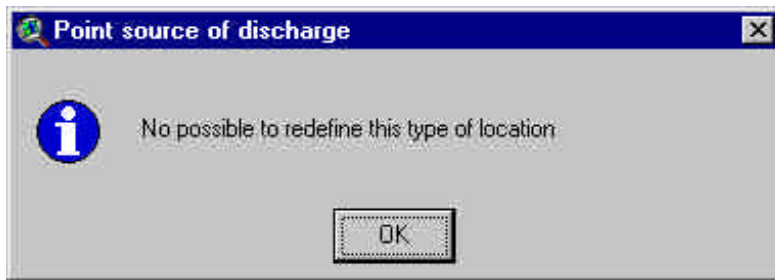
Screen 8.2.3.12

TUTORIAL:

(Optional) Activate the "Permit Compliance System" theme, select some locations and import them in the "Outlets" theme using the Inlet-AddTable-Permit Compliance System options.

(Optional) Manually add and/or remove some Point Sources, Inlets and Outlets

8.2.4 Main Watershed Outlet Selection and Definition

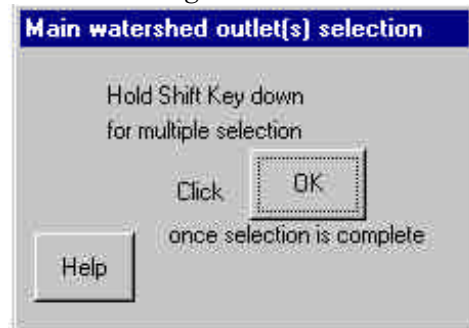This section (Screen 8.2.4.1) allows to complete the sub-watershed delineation process.
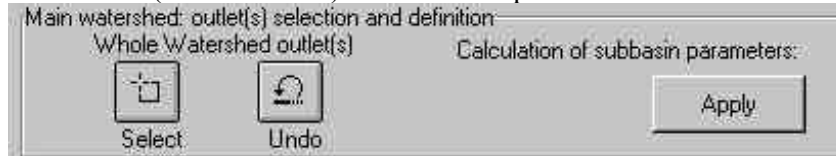
Screen 8.2.4.1

To start the final creation of the sub-watersheds, the user must select only the most downstream outlet(s)

of the watershed(s) to be delineated. Click the button labeled "Select".

The *DEM dialog* will minimize and another dialog will appear (Screen 8.2.4.2).
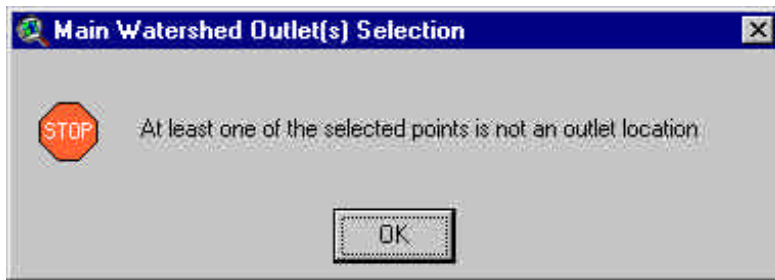
Screen 8.2.4.2

Type the **ESC** key to exit the selection

To select one watershed outlet, position the cursor close to the point chosen to be the watershed outlet. Hold down the left mouse button and move the mouse to form a box on the screen around the selected outlet(s). Release the left mouse button.

To select multiple not adjacent watershed outlets, hold down the shift key continuously while performing the actions described in Step 4 as many times as necessary to select all the watershed outlets of interest.

Tip: The tool allows multiple main watershed outlets to be selected. This feature allows non hydrologically connected watersheds to be simulated at the same time.

Once the outlet points are selected, click **OK** on the outlet selection prompt box. If a Point Discharge, Inlet of Draining Watershed or PCS location is specified, a dialog box will report an error and processing will stop (Screen 8.2.4.3).
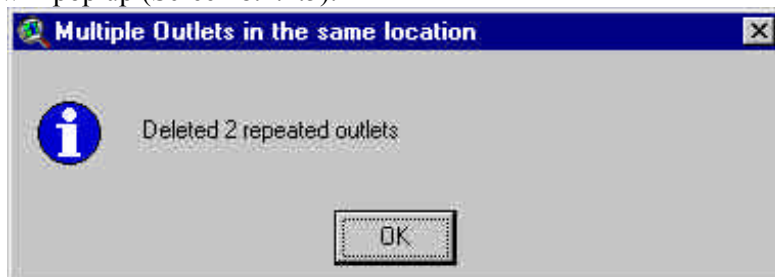
Screen 8.2.4.3

Otherwise a confirmation prompt pops up (Screen 8.2.4.4)
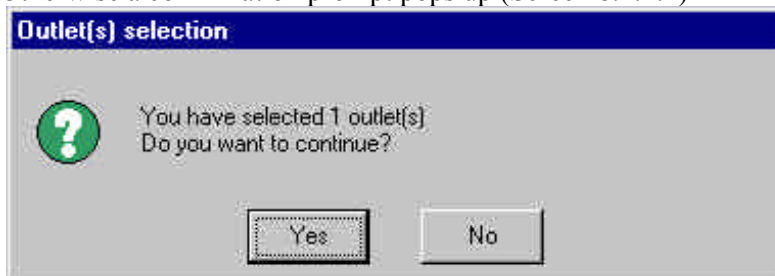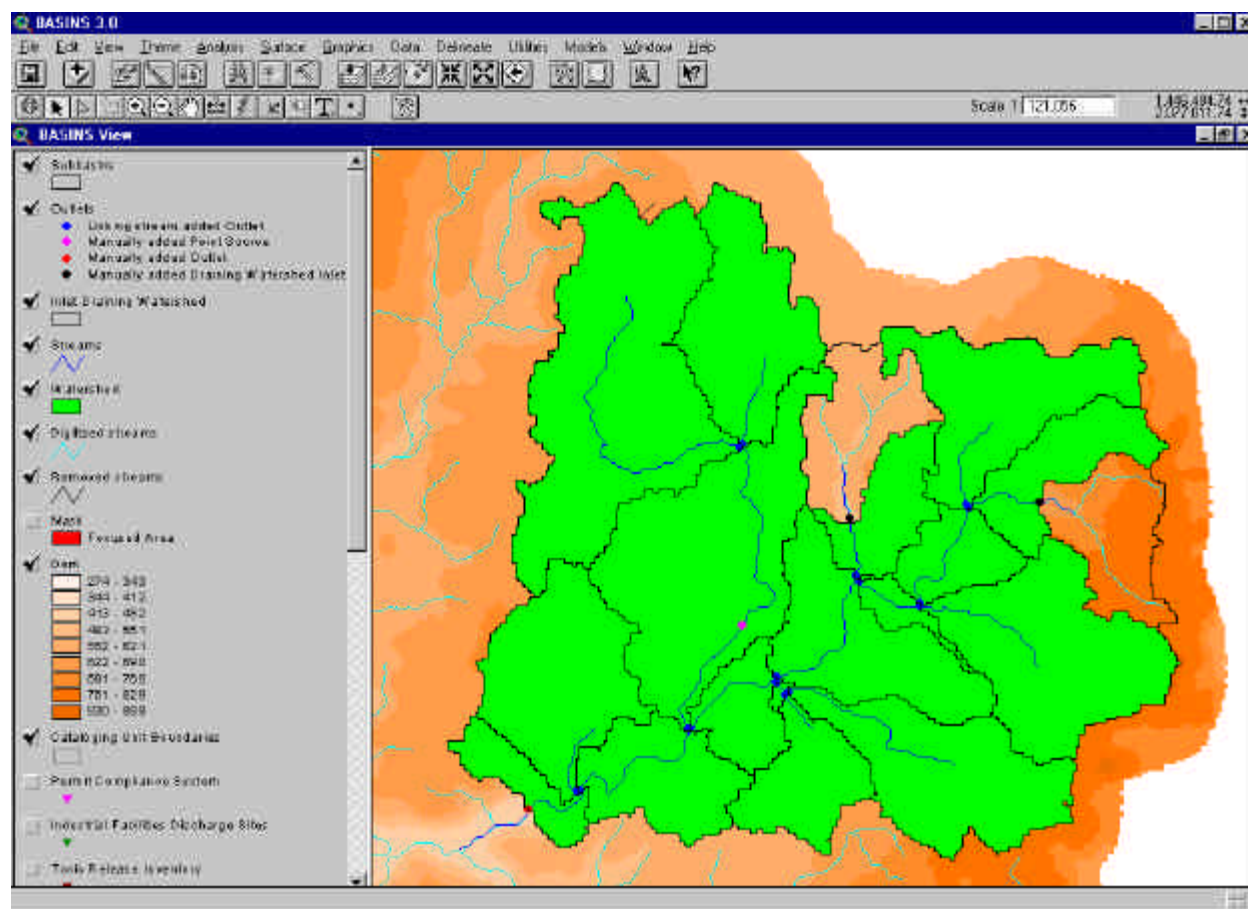

Screen 8.2.4.4

Click **Yes** to proceed.

Note: Repeated outlets (located in the same location) will be removed. In this case a message dialog
         will pop up (Screen 8.2.4.5).

Screen 8.2.4.5

A map of the watershed (*Watershed* theme), sub-watersheds (*Subbasins* theme), and stream network
restricted to the watershed (*Streams* theme) will appear on the screen when the interface has completed
the watershed delineation (Screen 8.2.4.6).

Screen 8.2.4.6

If one or more "Inlet of watershed" points are set on the stream network, the Inlet Draining Watershed theme is also added to the BASINS View (Screen 8.2.4.7).

Undo By clicking the button labeled "Undo" the user can step back and repeat steps 1-7. In fact this action will remove the watershed delineations and allow you to edit or re-select outlets and inlets for final delineation.

Click **Yes** to the prompt dialog to undo the last step (Screen 8.2.4.7).

Click **No** to continue with the current settings.

Screen 8.2.4.7

Calculation of Subbasin Parameters

This function calculates a set of geomorphic parameters for each subbasin and the relative stream reach. The results of the calculations are stored in the table of attributes of the updated *Subbasin* and *Streams* themes. See *Watershed Delineation Output Data* for the description of the stored data
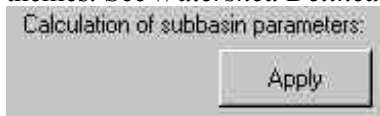
Click the **Apply** button located and labeled "Calculation of subbasin parameters:".

The calculation process ends when a dialog box appears signaling that the watershed and the sub units delineation are complete (Screen 8.2.4.8)
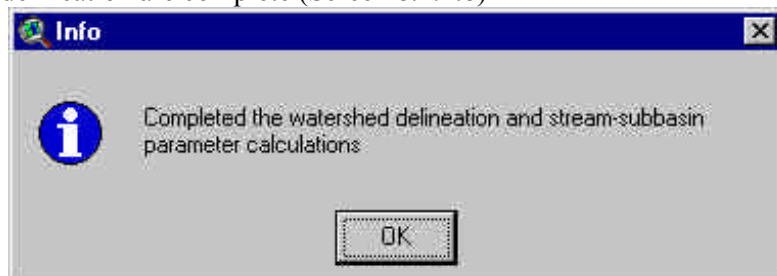
Screen 8.2.4.8

Note: Each subbasin is coupled to a single stream reach. If the user removed any outlet of the initial set, only the main stem will be considered in the final subbasin.

Each subbasin in the *Subbasins* theme is numbered and the label is visible in the View.

 The *Streams* theme is labeled as well if the burning option with Reach V3 or NHD has been used.

A new report named *Topographic Report* is now available (Screen 8.2.4.9). This report provides a statistical summary and distribution of discrete land surface elevations in the watershed and all the sub-watersheds.

Screen 8.2.4.9

TUTORIAL:

Manually add your main outlet point.

Select the same point as the Main Watershed Outlet

(Optional) Undo this selection and select a new main outlet

Apply the calculation of the parameters.

8.2.5 Reservoirs

Once the delineation is completed the user may optionally add or remove reservoir locations to complete or refine the hydraulic framework (Screen 8.2.5.1).
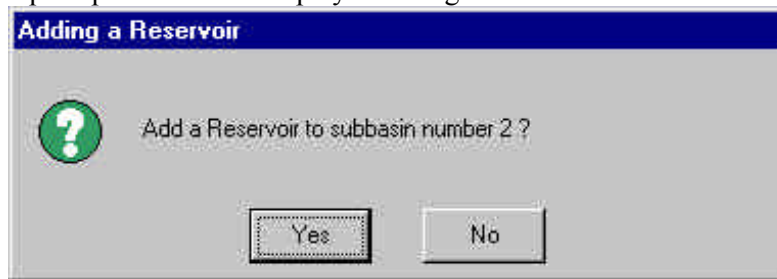
Adding a Reservior

Screen 8.2.5.1 Click on the **Add** button.

The dialog box will be minimized and the cursor will become a crosshair. Click over the target subbasin area to add a reservoir.
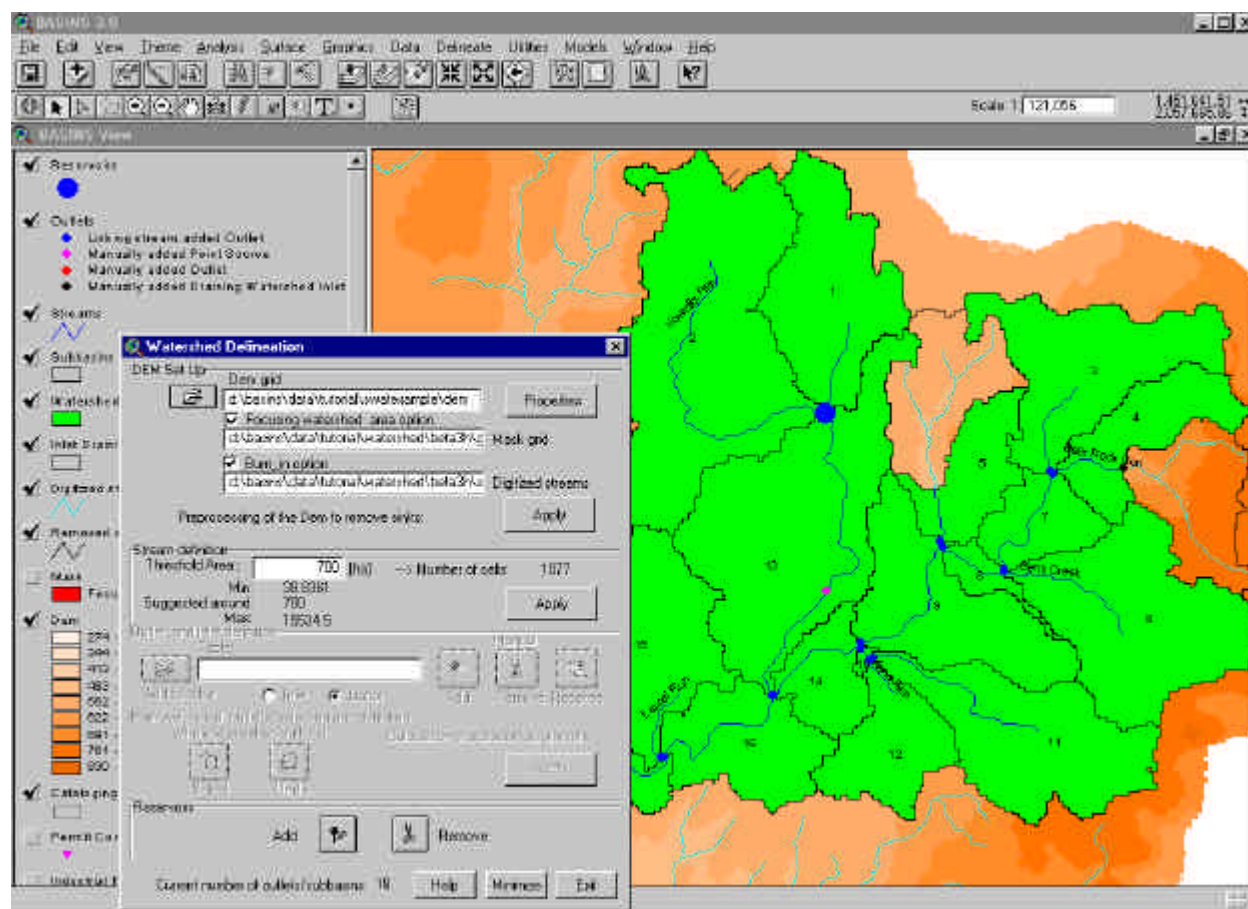
A prompt box will be displayed asking for verification of the reservoir placement (Screen 8.2.5.2).

Screen 8.2.5.2

If the wrong subbasin is listed, click **No** and repeat step 2. If the correct subbasin is listed, click **Yes**. The new reservoir location will be placed at the outlet of the respective subbasin.

Once the first reservoir location is added, the new *Reservoirs* theme will be added to the *BASINS View* (Screen 8.2.5.3).
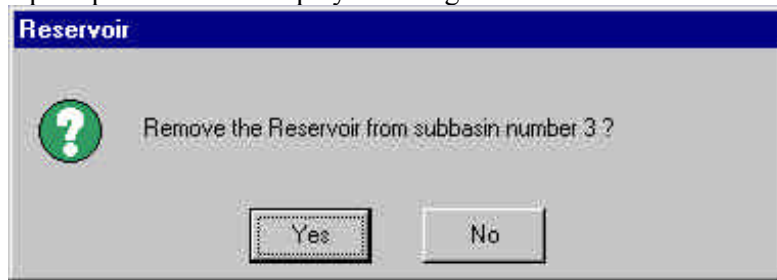
Screen 8.2.5.3

Tip: The user is allowed to add a single reservoir location for each subbasin. Refine the outlet set if more than one reservoir location needs to be set in the current subbasin area.

     Click the **Remove** button.

The *Watershed Delineation* dialog box will be minimized and the mouse cursor will become a square. Draw a square around the reservoir(s) you wish to remove by holding down the left mouse button.

A prompt box will be displayed asking for verification of the reservoir(s) removal (Screen 8.2.5.4).

Screen 8.2.5.4

If the wrong subbasin is listed, click **No** and repeat step 2. If the correct subbasin is listed, click **Yes**.

If all the reservoir locations are removed, the *Reservoirs* theme will be removed from the *BASINS View*.

TUTORIAL:

(Optional) Add and remove some or all the reservoirs.